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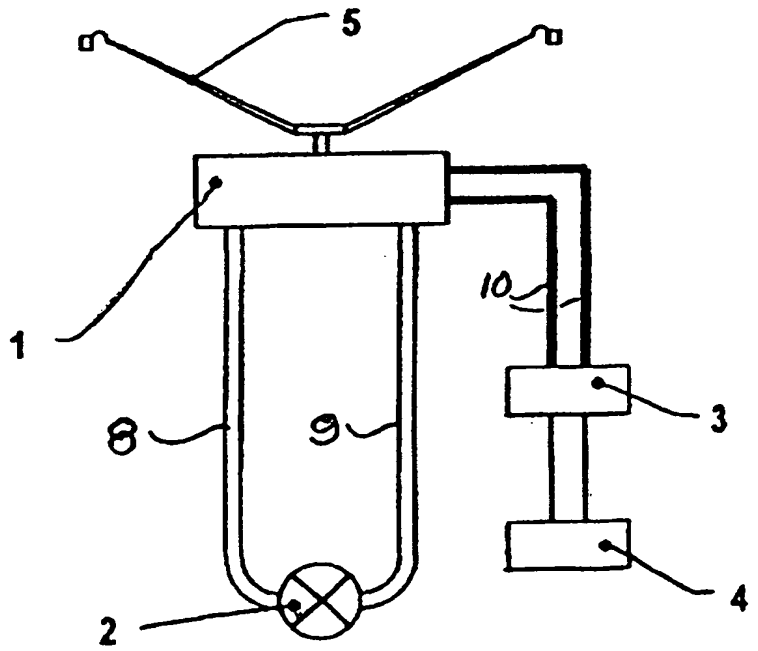
(54) Title: ACOUSTIC TRANSDUCERS USING A WORKING FLUID

(57) Abstract

The invention relates to the use, in an acoustic transducer (1) of an ER fluid as the working fluid; to an acoustic transducer (1) using an ER fluid as its working fluid; to the use of an ER fluid as the working fluid of a vibrator; to a vibrator employing an ER fluid as its working fluid.



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ACOUSTIC TRANSDUCERS USING A WORKING FLUID

Introduction

This invention is concerned with acoustic transducers, i.e. devices which convert electrical signals into mechanical vibrations in air, water or other media.

A sound, i.e. a series of successive waves of compression and rarefaction in a compressible medium, can be produced by two main methods:-

a) By vibrating a surface at the desired frequency. This is by far the commonest method. In standard units, the surface is usually a papier mache cone, which is light and stiff in compression, but other shapes and materials can be used. For the remainder of this application, the term "plate" will be used.

b) By allowing pulses at the desired frequency to escape from a continuous supply of the medium at elevated pressure: sirens are the chief example.

Under a), there are three main methods commonly used to move the plate:-

(i) A light coil is attached to the plate, and this is suspended in a radial magnetic field, normally produced by a permanent magnet. When a current is passed through the coil, it gives rise to an axial force, so the plate moves in accordance with the magnitude and direction of the current.

(ii) The plate may be moved electrostatically. With realistic fields, the force and displacement that can be achieved by this method are severely limited, so it is normally used only for high frequencies.

(iii) A stack of piezo-electric elements may be used to move the plate. This method can produce quite large forces, but the amplitude is relatively low. The response is poor at low frequencies, but very good at higher frequencies, so this is the method of choice for

underwater acoustic transducers used for sonar, which work at about 20kHz.

At present , only method (i) above can deal with the lower acoustic frequencies, below approximately 200 Hz. The sound intensity produced is governed by the area of the plate and the amplitude of its movement, and both of these are effectively limited by the force available. The acceleration required to achieve an oscillation at a given frequency and amplitude is proportional to the square of both parameters. The force required is proportional to the oscillating mass, so the latter is a key consideration. The mass of a plate of constant thickness will be proportional to its area, and in practice a larger plate will require additional stiffening. The overall result is that the acoustic output of a transducer at low frequencies is governed by the force that can be produced.

The force produced in an electromagnetic transducer is governed by the field, the performance of the permanent magnet, and the current through the coil, which is determined in turn by heat dissipation. Both of these are approaching the limits of existing materials, so it seems unlikely that electromagnetic transducers will greatly improve on their present practical limit on the mass of the oscillating element which is approximately 500g.

A basic object of the present invention is to provide an improved acoustic transducer overcoming the limitations of prior art proposals and thereby increasing the output of low to medium frequency acoustic transducers.

Accordingly, a first aspect of the present invention is directed to the use of an Electro-Rheological (ER) fluid as the working fluid of an acoustic transducer.

Another aspect, of independent significance is directed to an acoustic transducer employing an ER fluid as its working fluid.

Yet another aspect of independent significance is directed to the use of an ER fluid as the

working fluid of a vibrator.

Yet another aspect of independent significance is directed to a vibrator employing an ER fluid as its working fluid.

The invention thus makes a radical departure in the field of transducers and vibrators by employing ER fluids, which are concentrated suspensions of finely divided solids in oily base liquids which solidify, progressively, reversibly and virtually instantaneously, in an electric field. It is also well known that if ER fluids are pumped between two parallel fixed plates to which a voltage may be applied, the assemblage functions as a high-speed valve, and bi-directional actuators, in which such valves are combined with well-known hydraulic principles, have been described. However, the design of such actuators has largely followed conventional hydraulic practice, and, as a result, the frequency range of such units is limited. More recently, high frequency versions of these actuators have been the subject of another Patent Application, and it has been shown that these can be operated successfully up to at least 5kHz, making them suitable for use as acoustic transducers in the low to medium frequency range.

The technical advantages of ER vibrators as acoustic transducers are as follows:-

1. Since they operate on hydraulic principles, there are virtually no limits on the force that can be applied.

2. The main source of energy is the pump which operates continuously and need not be modulated. Hence, only the electrical control power need be modulated. This represents a considerable saving in cost, space and weight on conventional electro-magnetic practice which requires equipment to modulate the whole of the electrical input. Another aspect of this advantage is that the main power input need not be electrical. The pump may be driven hydraulically, pneumatically or even by a self-contained engine.

3. As in all hydraulic-type devices, waste heat is carried away in the working fluid and may be removed elsewhere in the circuit.

In one embodiment, ER vibrators are used directly to move a plate similar to that used in present loudspeakers. However, since the improved performance characteristics of the vibrators will remove existing limitations on mass, these plates can be made much larger than at present, and other constructional materials may be used.

In another embodiment, an ER vibrator is used to operate a high speed valve mechanism which allows pulses of air to escape from a pressurised reservoir. This aspect of the invention thus replaces the perforated disc used in conventional sirens with a high-frequency controllable valve. Although ER vibrators are ideal for this task, insofar that the mass of the moving parts is not critical, this aspect of the invention is not limited to this alone. Providing the valve itself is correctly designed, other actuators, such as electro-magnetic, electrostatic or piezo-electric could also be employed.

Various aspects of the invention will now be described in greater detail, by way of examples, with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic layout of a loudspeaker; and

Figure 2 corresponds to Figure 1 but shows a siren.

In both Figures, like reference numerals are employed for like components.

A high-speed ER actuator is indicated at 1 through which ER fluid is circulated via outlet and return lines 8 and 9 by a pump 2 running continuously at constant speed. A high voltage source 3 supplies high voltage signals to the ER actuator 1 via heavily insulated cables 10, which source 3 is, in turn, controlled by a low voltage source 4, for example a standard audio-amplifier. A cone 5, similar to a cone in a standard loudspeaker, serves to transfer the mechanical

movements of the output of the ER actuation 1 to the surrounding medium, e.g. air. However, due to the increased thrust capability of the ER actuator 1 compared with a standard electro-magnetic loudspeaker, this can be made larger and heavier than standard loudspeaker cones.

In Figure 2 a pump or blower 6 runs continuously, whilst a valve 7 is operated by the ER actuator 1 which modulates the output of the valve 7 in response to the signals from the high voltage source 3.

CLAIMS:

1. The use, in an acoustic transducer of an ER fluid as the working fluid.

2. An acoustic transducer, using an ER fluid as its working fluid with means to apply, in a controlled manner, an electric field to the ER fluid.

3. An acoustic transducer as claimed in Claim 2, comprising a pump for displacement of the ER fluid around a flow circuit.

4. An acoustic transducer as claimed in Claim 3, wherein the pump is continuously operable.

5. An acoustic transducer as claimed in Claim 3 or Claim 4, wherein the pump is driven hydraulically, pneumatically or even by a self-contained engine.

6. An acoustic transducer as claimed in any one of Claims 2 to 5, comprising means to modulate electrical control power providing the electric field.

7. The use of an ER fluid as the working fluid of a vibrator.

8. A vibrator employing an ER fluid as its working fluid.

9. A loud speaker comprising an ER vibrator as defined in Claim 8, operable directly on a movable loud speaker plate.

10. A siren comprising an ER vibrator as defined in Claim 8, operable on a high speed valve mechanism which allows pulses of air to escape from a pressurised reservoir.

Fig 2

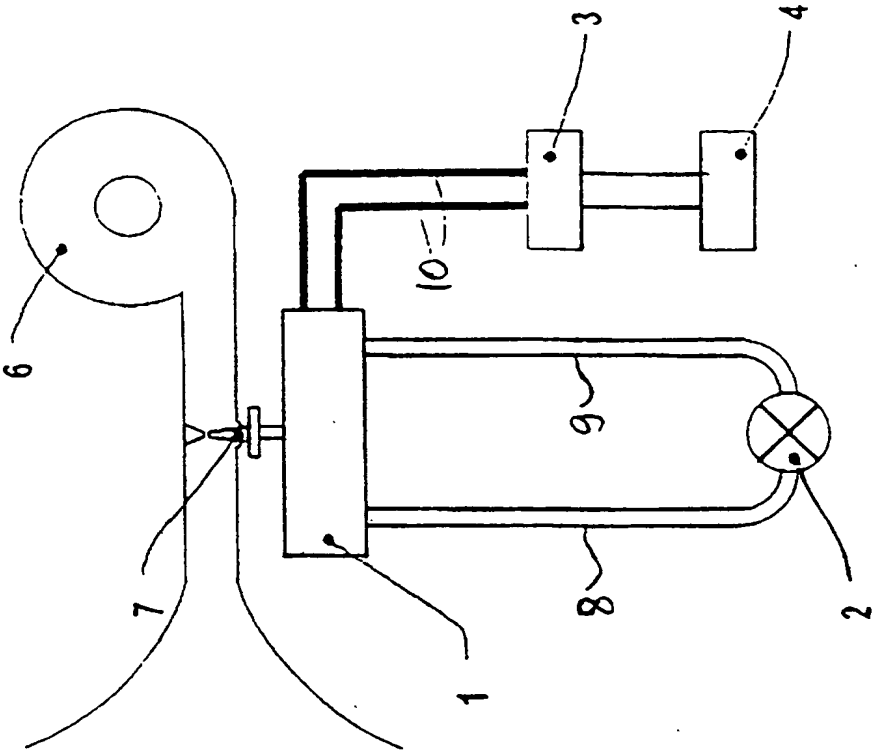
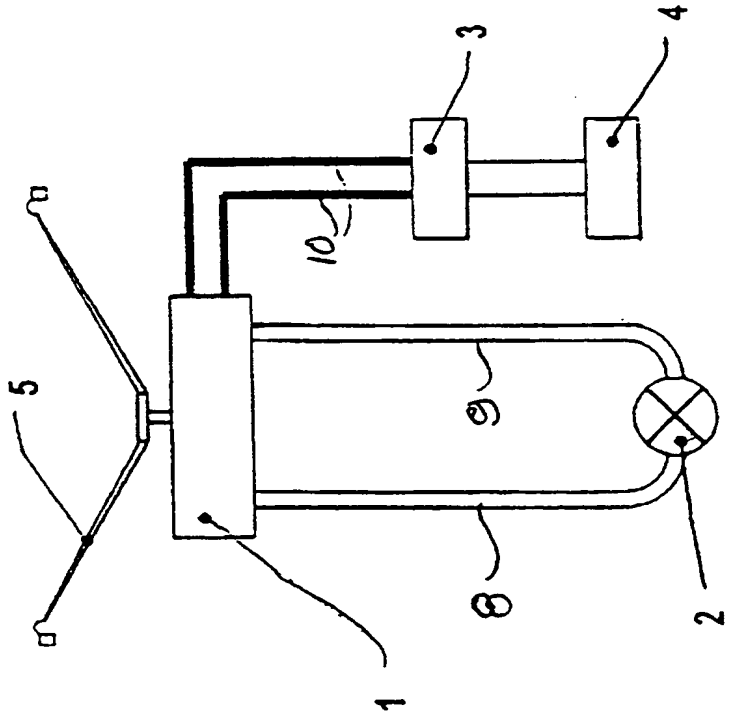


Fig 1



INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G10K9/08 G10K7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G10K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 218 576 A (DECHICO ROBERT A) 8 June 1993 see abstract see column 4, line 8 - line 33	1
A	WO 94 01979 A (NOISE CANCELLATION TECH ;PARRELLA MICHAEL J (US); MILLER SCOTT (US) 20 January 1994 see abstract; figure 4	1,9
X	AU 17480 83 A (SECR DEFENCE BRIT) 7 February 1985 see page 1A, line 23 - line 29 see page 3, line 17 - page 4, line 30; figure 1	7

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[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Z.P. SHUL'MAN ET AL: "Amplitude-frequency characteristics of an electrodynamic loudspeaker with magnetorheologic suspension" JOURNAL OF ENGINEERING PHYSICS, vol. 53, no. 6, December 1987, USA, pages 1424-1430, XP002044752 see page 1424, line 1 - line 18	9
A	US 1 571 378 A (W. SCHLOEMILCH) 2 February 1926 see claim 1; figure 1	10

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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